# PATENT SPECIFICATION

NO DRAWINGS

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COMPLETE SPECIFICATION

## Improvements in Stainless Steel

We, THE UNITED STEEL COMPANIES LIMITED, a British company, of The Mount, Broomhill, Sheffield 10, Yorkshire, formerly of 17, Westbourne Road, Sheffield 10, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

It is known that stainless steel can be hardened by precipitation if it is of closely controlled composition, a martensitic structure is developed in it, and it is then aged. If these steels are used at temperatures of 450°C and above, however, they tend to overage and soften rapidly.

We have now discovered that steels which will retain the high strength produced by precipitation up to higher temperatures can be produced if they are made of such composition as to precipitate two different phases, or in other words include two ageing systems.

The base composition of the steels according to the invention is from 0.03 to 0.12% carbon, from 15 to 18% chromium, from 3 to 7% nickel, from 1 to 3% maganese and up to 1% silicon. Of these alloying elements, chromium is used to impart stainlessness and nickel and manganese are used to limit the ferrite content of the miscrostructure.

One ageing system is formed by 0.5 to 5% cobalt + 0.5 to 3% molybdenum, and the other by copper, aluminium, niobium or titanium. Broadly, the steel may contain from 0 to 2% aluminium, from 0 to 3% copper, from 0 to 0.5% titanium and from 0 to 1% niobium, provided that one of the ageing system constituted by from 0.5 to 0.2% aluminium, from 0.5 to 3% copper, from 0.2 to 0.5% titanium and from 0.2 to 1% niobium is present. The balance, except for impurities, is iron.

[*Price 4s. 6d.*]

Various proposals have been made to manufacture steels containing the elements in question in varying amounts. The essence of the present invention is the inclusion of the two ageing systems in austenitic steels of the limited base composition set forth above.

The exact composition of the steel according to the invention is determined by the desirability of reducing the amount of delta ferrite, which is undesirable since it leads to a reduction in strength and also makes the steel difficult to hot-work, and by the undesirability of reducing the martensite transformation range too much.

The reason why the martensitic transformation range is important is that the steels according to the invention are first put into the austenitic state by a solution heat- treatment, and are fabricated in this state, being converted to the martensitic state before being put into service. The conversion to the martensitic state is effected by heat treatment. One heat treatment comprises heating commonly called "primary tempering", to cause precipitation of chromium carbide, say at 700°C for 2 hours. Since this lowers the amount of both chromium and carbon in solid solution, the martensite transformation range is raised. Cooling to room temperature now causes the steel to pass through the martensite range and hardening will ocurr. An alternative heat-treatment comprises cooling the steel below the transformation range, say at about −80°C.

Thus in determining the composition of any steel according to the invention it is necessary to take into account the effect of the elements that form the precipitable phases on the martensite transformation range (Ms) and also their effect in forming delta ferrite. These effects can be summarised as follows:—

to the invention is that they are not dependent on complete transformation to martensite prior to secondary tempering and therefore the control of martensite transformation does not need to be very accurate. The phases precipitate more easily from a martensitic matrix than an austenitic matrix, and providing the majority of the structure is martensitic appreciable hardening can be obtained. Starting from the refrigerated condition the hardness can be raised quite easily to 450 to 500 VPN, and, even more important, starting from the primary tempered condition where the initial hardness is lower, say 350 VPN, the hardness can still be raised to 450 VPN.

WHAT WE CLAIM IS:—

1. Steel containing from 0.03 to 0.12% carbon, from 15 to 18% chromium, from 3 to 7% nickel, from 1 to 3% manganese and up to 1% silicon, from 0.5 to 5% cobalt, from 0.5 to 3% molybdenum, together with from 0 to 2% aluminium, from 0 to 3% copper, from 0 to 0.5% titanium and from 0 to 1% niobium, the amounts of these last four elements being such that the steel contains one of the ageing systems constituted by from 0.5 to 2% aluminium, from 0.5 to 3% copper, from 0.2 to 0.5% titanium and from 0.2 to 1.0% niobium; the balance except for impurities being iron.

2. Steel containing from 0.03 to 0.12% carbon, from 15 to 18% chromium, from 3 to 7% nickel, from 1 to 3% manganese and up to 1% silicon, together with from 0.5 to 5% cobalt + from 0.5 to 3% molybdenum and from 0.5 to 2% aluminium, the balance except for impurities being iron.

3. Steel having the following composition:— carbon 0.03 to 0.12%, manganese 1 to 3%, silicon up to 1%, chromium 15 to 17%, nickel 4 to 7%, molybdenum 1 to 2%, cobalt 0.5 to 5%, and aluminium 0.5 to 1%, the balance except for impurities being iron.

4. Steel containing from 0.03 to 0.12% carbon, from 15 to 18% chromium, from 3 to 7% nickel, from 1 to 3% manganese and up to 1% silicon, together with from 0.5 to 5% cobalt + from 0.5 to 3% molybdenum and from 0.5 to 3% copper, the balance except for impurities being iron.

5. Steel having the following compositions; carbon 0.03 to 0.12%, manganese 1 to 3%, silicon up to 1%, chromium 16 to 18%, nickel 3 to 6%, molybdenum 1 to 2%, cobalt 0.5 to 5% and copper 0.5 to 3%, the balance except for impurities being iron.

6. A process of treating a steel according to any of the preceding claims which comprises solution-treating the steel to render it austenitic, fabricating it in this state, and transforming the fabricated steel to the mortensitic state.

7. A process according to claim 6 in which the steel is precipitation-hardened by heat treatment after the transformation to the martensitic state.

8. A steel article precipitation-hardened by a process according to claim 7.

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